## Submission 24

**Comments on the difficulty of testing hypotheses regarding extra mortality, and on the regime shift under the Alpha and Delta models**

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### 1. Comment on difficulty of testing hypotheses regarding extra mortality of non-transported Snake River spring/summer chinook.

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Three hypotheses are simulated in the BSM regarding post-Bonneville survival of non-transported spring/summer Snake River chinook (referred throughout this note by the symbol "$\lambda_n$"). Those hypotheses describe three basic patterns for future values of $\lambda_n$:

(1) $\lambda_n$ will continue at recent values into the indefinite future, irrespective of any management action. This is called the "BKD" hypothesis.

(2) $\lambda_n$ will continue at recent values, unless in-river passage survival is increased. This is called the "hydro" hypothesis. Substantial changes in in-river passage survival occur if Snake River dams are removed, which is our current modeled A3 scenario (draw-down).

(3) $\lambda_n$ will cycle at 30 year intervals, continuing at recent values until year 2005 then change to pre-1970 values for another 30 years etc. This is called the "Regime Shift" hypothesis. The shift might better be called the "differential Snake River Regime Shift" hypothesis because a common year-effect is already modeled in the "delta" life-cycle model and because the Snake River is assumed to have separate distinct region effects in the "alpha" model.

All three hypotheses pertain to changes in $\lambda_n$ which have occurred during the last 20 years or so. The last Snake River dam (Lower Granite) went in to operation in 1975 (potentially affecting brood year 1973 to current under the "hydro" hypothesis). The Regime Shift cycle is assumed to have changed phases beginning in 1977 (potentially affecting brood year 1975 to current under the "Regime shift" hypothesis). The BKD hypothesis could have begun during those years, earlier, or later.

Therefore, all three hypotheses predict a "one-way trip" in the observed spawner-recruit data with $\lambda_n$ generally decreasing in recent years as compared to earlier years. Furthermore the hypotheses all predict nearly the same starting date of a big change in $\lambda_n$, particularly if the last Snake River dam is disproportionally responsible for decreases in $\lambda_n$. Some attempts have been made to accept or reject some of these hypotheses, particularly in the recent notes by Hinrichsen. His approach has been based on analyses involving the specific mechanics about how the above

3 hypotheses have been implemented in BSM. While those analyses have been useful to encourage us to examine the hypotheses in more fundamental detail, they basically dodge the basic problem that we're dealing with three alternative hypotheses that are fundamentally similar in their expectations about past patterns of $\lambda_n$. I've shown elsewhere, for example, that a simple alternative representation of the "hydro" hypothesis yields jeopardy probabilities similar to those in the current implementation of BSM.

I've constructed some graphs and made some correlations that I hope will be useful to the reader to better understand the interaction between "D" – the ratio of transport to non-transport fish post-Bonneville survival factor – and $\lambda_n$ and passage model. The graphs are constructed from delta model MLE estimates.

A few qualifiers:

(1) The delta model contains 86 parameters and many of the parameters have large covariances, which is particularly true for the "mu" parameters that were transformed to obtain the [1-$\lambda_n$] estimates shown in the Figures. There is no statistical basis for conducting hypothesis testing by application of "t-tests" on groups of those ML transformed $\lambda_n$ estimates (e.g. in Hinrichsen's recent papers) so I've not done such here, nor do I think it is particularly useful given the one-way trip that the alternative models all describe.

(2) I've used the PDO index as an indicator of climate regimes, as developed by Mantua et al (1997, "A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production"). There are alternative indices and the lack of an exact environmental feature is one of the difficulties in making a rigorous examination of the hypothesis (3).

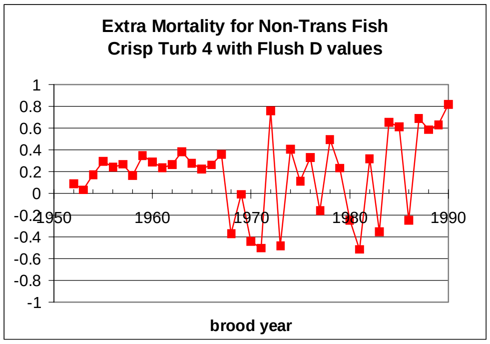
(3) The $\lambda_n$ estimates are obtained by factoring out several passage model inputs and thus the $\lambda_n$ reflect all errors in those inputs. The errors are potentially quite large, especially during the 1970's, due to lack of adequate data to support all the passage model inputs – particularly the "D" values.

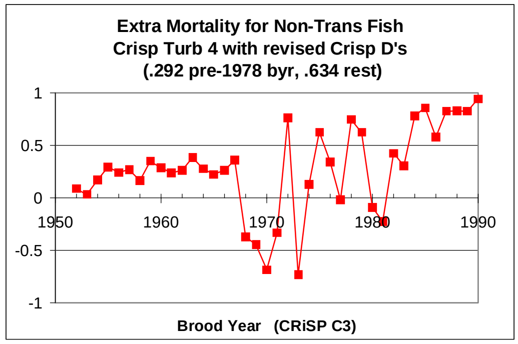
Observations I've made from the graphs and correlations:

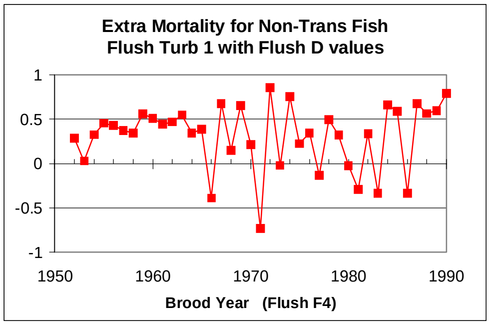
1. Crisp and Flush passage models produce similar ML estimates of the [1-$\lambda_n$] (extra mortality of non-transported smolts) when they use the same set of D values (D is the ratio of transported to non-transported fish post-Bonneville survival factor). ML refers to Maximum Likelihood conditioned on given passage model input.
2. Crisp and Flush passage models produce higher correlations (0.31-0.40) between the ML estimate of [1-$\lambda_n$] and the PDO index when they use the Crisp set of D values. With the Flush set of D values, the correlations with PDO range from 0.02 to 0.20.
3. Crisp and Flush passage model similarity is higher in the 1970-1990 brood year data. The 1970 brood year was selected for this starting point because that is the first year for which the delta model provides year-specific parameters for total passage+extra mortality.

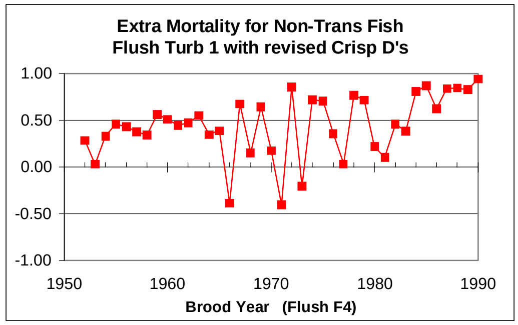
4. The period of 1969-1979 brood years is a period of large positive and negative fluctuations in the ML estimates of [1-$\lambda_n$] for all passage models, but one which was strongly trending to an unfavorable climate period as indicated by the PDO index. The delta model year-effect has a time trend similar to the PDO index during that time period. For reference, four of the eight dams all went into operation from brood year 1966 to 1973.
5. The recent (1987-1989) brood years show high ML estimates of extra mortality (1-$\lambda_n$) in all models in contrast to what is indicated to be a favorable climate period by the PDO index. The delta model ML estimates of year-effect indicates unfavorable climate in two of the three years.
6. During some periods of years, the time trend in the MLE delta model year-effect and the PDO index is similar, but overall the two indices are not strongly correlated.

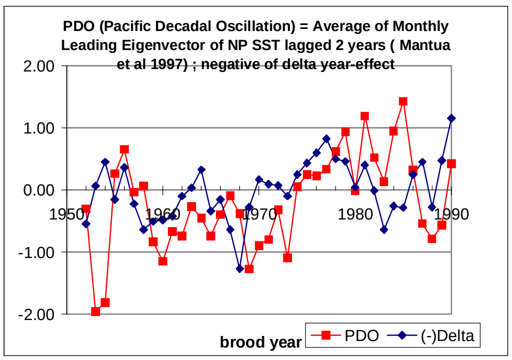
The main conclusion I draw from the graphs is that the "D" values are at least as important as other passage model input in determining the pattern of $\lambda_n$, and more important for any kind of match with the PDO.

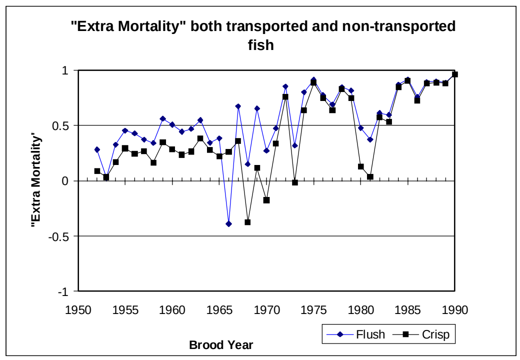

Extra Mortality for Non-Trans Fish
Crisp Turb 4 with Flush D values
brood year


Extra Mortality for Non-Trans Fish
Crisp Turb 4 with revised Crisp D's
(.292 pre-1978 byr, .634 rest)
Brood Year (CRiSP C3)


Extra Mortality for Non-Trans Fish
Flush Turb 1 with Flush D values
Brood Year (Flush F4)


Extra Mortality for Non-Trans Fish
Flush Turb 1 with revised Crisp D's
Brood Year (Flush F4)


PDO (Pacific Decadal Oscillation) = Average of Monthly Leading Eigenvector of NP SST lagged 2 years ( Mantua et al 1997) ; negative of delta year-effect
brood year
PDO
(-)Delta


"Extra Mortality" both transported and non-transported fish
"Extra Mortality"
Brood Year
Flush
Crisp

Correlation Matrix - all data

| data for brood years | | Extra Mortality of non-transported fish =(1-L_n) | | | | | Extra Mort =[1-e^(M-m)] | | (-) delta |
|---|---|---|---|---|---|---|---|---|---|
| 1952-1990 | | Crisp right | Crisp left | Flush right | Flush left | PDO | Flush | Crisp | yr-effect |
| 1-L_n | Crisp right | 1.00 | | | | | | | |
| " | Crisp left | 0.83 | 1.00 | | | | | | |
| " | Flush right | 0.75 | 0.74 | 1.00 | | | | | |
| " | Flush left | 0.49 | 0.80 | 0.80 | 1.00 | | | | |
| | PDO | 0.40 | 0.16 | 0.31 | 0.02 | 1.00 | | | |
| 1-e^(M-m) | Flush | 0.62 | 0.49 | 0.81 | 0.50 | 0.42 | 1.00 | | |
| " | Crisp | 0.85 | 0.66 | 0.67 | 0.34 | 0.46 | 0.83 | 1.00 | |
| (-)delta | yr-effect | 0.26 | 0.19 | 0.14 | 0.01 | 0.21 | 0.37 | 0.49 | 1.00 |

Correlation Matrix - 1970+ data

| data for brood years | | Extra Mortality of non-transported fish =(1-L_n) | | | | | Extra Mort =[1-e^(M-m)] | | (-) delta |
|---|---|---|---|---|---|---|---|---|---|
| 1970-1990 | | Crisp right | Crisp left | Flush right | Flush left | PDO | Flush | Crisp | yr-effect |
| 1-L_n | Crisp right | 1.00 | | | | | | | |
| " | Crisp left | 0.86 | 1.00 | | | | | | |
| " | Flush right | 0.90 | 0.87 | 1.00 | | | | | |
| " | Flush left | 0.63 | 0.91 | 0.81 | 1.00 | | | | |
| | PDO | 0.38 | 0.20 | 0.32 | 0.09 | 1.00 | | | |
| 1-e^(M-m) | Flush | 0.94 | 0.87 | 0.86 | 0.67 | 0.31 | 1.00 | | |
| " | Crisp | 0.94 | 0.82 | 0.79 | 0.57 | 0.32 | 0.98 | 1.00 | |
| (-)delta | yr-effect | 0.12 | 0.19 | 0.10 | 0.17 | 0.11 | 0.24 | 0.21 | 1.00 |

Data used in Figures

| brd yr | Crisp right | Crisp left | Flush right | Flush left | PDO | Flush | Crisp | year effect |
|---|---|---|---|---|---|---|---|---|
| | Extra Mortality of non-transported fish | | | | | Extra Mortality | | -delta |
| 1952 | 0.09 | 0.09 | 0.28 | 0.28 | -0.31 | 0.28 | 0.09 | -0.55 |
| 1953 | 0.03 | 0.03 | 0.03 | 0.03 | -1.96 | 0.03 | 0.03 | 0.06 |
| 1954 | 0.17 | 0.17 | 0.32 | 0.32 | -1.82 | 0.32 | 0.17 | 0.45 |
| 1955 | 0.29 | 0.29 | 0.45 | 0.45 | 0.26 | 0.45 | 0.29 | -0.16 |
| 1956 | 0.24 | 0.24 | 0.43 | 0.43 | 0.65 | 0.43 | 0.24 | 0.36 |
| 1957 | 0.27 | 0.27 | 0.37 | 0.37 | -0.04 | 0.37 | 0.27 | -0.22 |
| 1958 | 0.16 | 0.16 | 0.34 | 0.34 | 0.06 | 0.34 | 0.16 | -0.64 |
| 1959 | 0.35 | 0.35 | 0.56 | 0.56 | -0.84 | 0.56 | 0.35 | -0.51 |
| 1960 | 0.29 | 0.29 | 0.51 | 0.51 | -1.15 | 0.51 | 0.29 | -0.49 |
| 1961 | 0.24 | 0.24 | 0.44 | 0.44 | -0.67 | 0.44 | 0.24 | -0.43 |
| 1962 | 0.26 | 0.26 | 0.47 | 0.47 | -0.75 | 0.47 | 0.26 | -0.10 |
| 1963 | 0.38 | 0.38 | 0.55 | 0.55 | -0.27 | 0.55 | 0.38 | 0.03 |
| 1964 | 0.28 | 0.28 | 0.34 | 0.34 | -0.46 | 0.34 | 0.28 | 0.32 |
| 1965 | 0.22 | 0.22 | 0.38 | 0.38 | -0.74 | 0.38 | 0.22 | -0.34 |
| 1966 | 0.26 | 0.26 | -0.39 | -0.39 | -0.40 | -0.39 | 0.26 | -0.16 |
| 1967 | 0.36 | 0.36 | 0.67 | 0.67 | -0.09 | 0.67 | 0.36 | -0.64 |
| 1968 | -0.37 | -0.37 | 0.15 | 0.15 | -0.38 | 0.15 | -0.37 | -1.27 |
| 1969 | -0.44 | -0.01 | 0.64 | 0.65 | -1.28 | 0.66 | 0.12 | -0.28 |
| 1970 | -0.69 | -0.44 | 0.17 | 0.21 | -0.90 | 0.27 | -0.18 | 0.17 |
| 1971 | -0.33 | -0.51 | -0.41 | -0.73 | -0.80 | 0.47 | 0.34 | 0.09 |
| 1972 | 0.76 | 0.76 | 0.85 | 0.85 | -0.32 | 0.85 | 0.76 | 0.07 |
| 1973 | -0.73 | -0.48 | -0.21 | -0.02 | -1.10 | 0.32 | -0.02 | -0.10 |
| 1974 | 0.13 | 0.40 | 0.72 | 0.75 | 0.05 | 0.80 | 0.64 | 0.25 |
| 1975 | 0.63 | 0.11 | 0.70 | 0.22 | 0.24 | 0.91 | 0.88 | 0.43 |
| 1976 | 0.34 | 0.33 | 0.35 | 0.34 | 0.22 | 0.78 | 0.75 | 0.59 |
| 1977 | -0.02 | -0.16 | 0.03 | -0.13 | 0.33 | 0.69 | 0.64 | 0.82 |
| 1978 | 0.74 | 0.49 | 0.76 | 0.49 | 0.62 | 0.85 | 0.83 | 0.50 |
| 1979 | 0.62 | 0.23 | 0.71 | 0.32 | 0.94 | 0.82 | 0.75 | 0.46 |
| 1980 | -0.09 | -0.25 | 0.22 | -0.03 | -0.02 | 0.48 | 0.13 | 0.04 |
| 1981 | -0.23 | -0.52 | 0.10 | -0.29 | 1.19 | 0.37 | 0.03 | 0.40 |
| 1982 | 0.42 | 0.32 | 0.45 | 0.34 | 0.52 | 0.61 | 0.57 | -0.01 |
| 1983 | 0.30 | -0.35 | 0.38 | -0.34 | 0.13 | 0.60 | 0.53 | -0.64 |
| 1984 | 0.78 | 0.65 | 0.80 | 0.66 | 0.95 | 0.87 | 0.85 | -0.26 |
| 1985 | 0.86 | 0.61 | 0.87 | 0.59 | 1.43 | 0.91 | 0.90 | -0.29 |
| 1986 | 0.58 | -0.25 | 0.62 | -0.33 | 0.32 | 0.76 | 0.73 | 0.25 |
| 1987 | 0.82 | 0.69 | 0.84 | 0.67 | -0.54 | 0.89 | 0.88 | 0.45 |
| 1988 | 0.83 | 0.58 | 0.84 | 0.56 | -0.79 | 0.90 | 0.89 | -0.28 |
| 1989 | 0.82 | 0.63 | 0.83 | 0.59 | -0.57 | 0.89 | 0.88 | 0.47 |
| 1990 | 0.94 | 0.82 | 0.94 | 0.79 | 0.42 | 0.96 | 0.96 | 1.16 |

## 2. Why Regime Shift Doesn't Help FLUSH and Does Help CRiSP

I looked at the diagnostics below to determine the cause of the differences in response to the regime shift hypothesis with FLUSH/T1 vs CRISP/T4. As seen below for Flush, the reason total mortality in prospective years ($m_y$) is similar in both phases of the cycle is because the reduction in retrospective system survival ($\omega_r$) offsets reductions in retrospective total mortality, $m_r$ (going from + to - cycle phase). Prospective system survival ($\omega_y$) doesn't change. The offset is larger for the Flush model than the Crisp model mainly because "D" is lower in recent years for the Flush model (around 0.3) than for the Crisp model (around 0.6).

| | Crisp | | Flush | |
|---|---|---|---|---|
| Cycle Phase | (+) | (-) | (+) | (-) |
| $\ln(\omega_y / \omega_r)$ | 0.32 | 0.43 | -0.72 | 0.19 |
| $m_r$ | 1.15 | 2.15 | 1.15 | 2.15 |
| $m_y$ | 0.84 | 1.72 | 1.87 | 1.96 |
| ln(R/S) | 0.83 | 0.55 | 0.60 | 0.59 |
| $\omega_y$ | 0.53 | 0.53 | 0.23 | 0.23 |
| $\omega_r$ | 0.43 | 0.36 | 0.53 | 0.20 |

notes:

Quantities are calculated for 200 X 100 year prospective simulation

(+), (-) indicate positive/negative regime phase

For the regime hypothesis, $m_y = m_r - \ln(\omega_y/\omega_r)$